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AN EVALUATION OF A DISEQUILIBRIUM MODEL

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Preface

This publication is a lightly edited version of an unusually comprehensive term paper prepared by Carol A. Ferguson. The paper contains a useful review of the literature on disequilibrium models and an analysis of a model of the fed beef sector developed by Ziemer and White. Carol's work also provides insights into the difficulties of estimating disequilibrium models, especially those with autocorrelated residuals, and it compares a number of estimators of the equilibrium version of the fed beef model. In addition, the results illustrate the sensitivity of parameter estimates to errors in observations, which were contained in the original data set. Ziemer and White's article was used because it was accessible and provided a useful vehicle for the appraisal of disequilibrium econometrics, and not because we wished to single them out for criticism. Indeed, we gratefully acknowledge Professor Ziemer's willingness to provide his original data file, which is used in Carol's analysis.

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Revitalized by Barro and Grossman, disequilibrium analysis has opened up new lines of inquiry in recent economic thought. Theoretical developments in this area are continuing, but while disequilibrium is much discussed in the theoretical literature, applied economists have made little formal use of this approach. In agricultural economics, Ziemer and White present one of the few attempts to apply a disequilibrium model (see also Baumes and Womack).

Ziemer and White's "Disequilibrium Market Analysis: An Application to the U.S. Fed Beef Sector" serves as a focal point for this paper, one objective of which is to review and critique their article. Accompanying this is a larger objective of an overall evaluation of the disequilibrium approach, its advantages, disadvantages, and potential for further use in applied economics.

The second section of this paper summarizes the Ziemer and White article. Criticisms - theoretical, empirical, and statistical - are covered in the following section. Based upon these criticisms, Ziemer and White's econometric models are re-estimated. Regression results are presented in the fourth section, along with an evaluation of the forecasting ability of the different models. The fifth section examines the advantages and disadvantages of the empirical use of current versions of the disequilibrium model, and possible directions for the future. A brief restatement of conclusions is given last.

Review of a Disequilibrium Market Analysis Model

Ziemer and White present a generalized, single-market version of both an equilibrium and a disequilibrium model of the fed-beef sector. Both models have a supply and demand relationship as a base, with the quantity demanded or supplied as a function of price and exogenous factors. One important qualification, relevant to the development of disequilibrium models, must be made about these relationships: the quantities referred to here are the "desired level of transactions" for each side of a market. In the disequilibrium literature, these are often called the "notional" or "Walrasian" supply and demand. They are the solutions theoretically derived by utility-maximizing consumers and profit-maximizing firms who may buy or sell in unlimited quantities at a given, market price. In

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disequilibrium, agents face quantity constraints on the level of transactions, creating a divergence between these notional relationships and "effective" supply and demand, which incorporate perceived quantity constraints.

From this base of supply and demand, Ziemer and White close their generalized equilibrium model with two market-clearing relationships involving price and inventory adjustments. A simpler equilibrium specification (and that actually used by Ziemer and White in estimation) would be to equate quantity demanded with quantity supplied. The disequilibrium model distinguishes itself by not requiring notional supply and demand to be equal, and this may itself be taken as a definition of disequilibrium. Instead, a third quantity is introduced into the model, the actual quantity transacted. The disequilibrium model is closed by equating this latter quantity with the minimum of notional supply and demand and adding a Walrasian price adjustment equation.

Ziemer and White next discuss the possible causes of disequilibrium, both in general terms and with respect to specific causes of disequilibrium in the U.S. fed beef market. From Carlton, markets which do not clear exhibit three general features, and each is necessary for there to be true disequilibrium: uncertainty, price inflexibility, and production lags. The reasons for disequilibrium given by Ziemer and White fit well into this framework.1/

First, they mention extreme weather conditions as a general source of uncertainty in agriculture, one possibly leading to disequilibrium. In addition, a high income elasticity of demand is cited as a particular cause of disequilibrium in the fed beef market. This assumedly refers to greater uncertainty about demand conditions by producers.

As for price inflexibility, Ziemer and White rely mostly on an imperfect information explanation, and this is the most common argument used in disequilibrium analysis. Price sluggishness has been specifically associated with the following: within a search context, the role of prices as signals; the pricing policies of sellers capitalizing on the temporary monopoly power of a disequilibrium situation; the result of a seller's learning process about the parameters of an unknown demand curve. Other reasons given for price inflexibility involve transactions costs to adjusting prices (Carlton; Gordon and Hynes; Gordon; Grossman; Barro; Sahling).

In identifying possible causes of disequilibrium in the fed beef market, Ziemer and White extend the above imperfect information argument to include asymmetric information, that is, an informational advantage of some market participants over others. This, in conjunction with market concentration on both sides of the fed beef market, is said to lead actual price away from that which would prevail under competitive conditions. An additional

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1/ For the most part, this paper will consider the problems of modelling disequilibrium situations within a market economy; that is, where disequilibrium occurs due to a private market failure or imperfection rather than government controls.

reason given for disequilibrium prices is the price inflexibility created by the government wage and price controls in effect between 1971 and 1974.

The final component of disequilibrium is production lags, costs and constraints preventing instantaneous adjustment of quantities. Here Ziemer and White cite the long production cycles characteristic of agriculture as limiting quantity flexibility, with fed beef constrained by the length of the feeding cycle and the high costs to withholding livestock on feedlots.

After introducing the generalized disequilibrium model and establishing a case for a disequilibrium approach to the beef market, Ziemer and White specify the following model to be estimated:

$$(1)\quad D_t = \alpha_0 + \alpha_1 UCP_t + \alpha_2 HP_t + \alpha_3 Y_t + \alpha^* P_t + u_t$$

$$(2)\quad S_t = \beta_0 + \beta_1 PC_{t-2} + \beta_2 C_t + \beta^* P_t + v_t$$

$$(3)\quad Q_t = MIN(D_t,\ S_t)$$

$$(4)\quad dP_t \equiv P_t - P_{t-1} = \lambda(D_t - S_t)$$

where D_t and S_t are the notional demand and supply of fed beef, and Q_t is the observed quantity of fed beef transacted. Specific definitions and other information about the variables are given in Table 1. The error terms, u_t and v_t, are assumed to be normally distributed random variables with zero means and finite variances.2/

As specified above, the system (1)-(4) presents an estimation problem since it involves unobservable variables: D_t is unobservable when there is excess demand and price is rising ($dP_t>0$), and S_t is unobservable in times of excess supply when price is falling ($dP_t<0$). One approach to estimation, Fair and Jaffee's quantitative method, involves the following substitutions to eliminate the unobservables:

$$(5)\quad Q_t = MIN(D_t,\ S_t) = S_t \quad \text{if } dP_t>0,$$

$$(6)\quad Q_t = MIN(D_t,\ S_t) = D_t \quad \text{if } dP_t<0,$$

so substituting (1) and (5) into (4) we obtain

$$(7)\quad Q_t = \alpha_0 + \alpha_1 UCP_t + \alpha_2 HP_t + \alpha_3 Y_t + \alpha^* P_t - \lambda^* dP_t^+ + u_t\ ,$$

2/ Though not directly stated, the estimator used by Ziemer and White implies two additional assumptions on u_t and v_t: both are assumed to be serially uncorrelated, and the contemporaneous covariance between u_t and v_t is assumed to be zero.

Table 1

Variable Definitions for Fed Beef Model

Symbol	Variable	Units	Sample Mean
C	Price of corn, received by farmers	\$/10 bu.	17.30
HP	Price of hogs, barrows and gilts, 7 markets	\$/cwt.	31.85
P	Price of fed beef, Omaha, 900-1100 lb. choice	\$/cwt.	37.39
PC_{-2}	Placement of cattle on feed, lagged two quarters	1,000 head	6047
Q	Fed beef marketings, live weight a/	m. lb.	6010
UCP	Price of utility cows, Omaha	\$/cwt.	24.86
Y	Per capita personal income, deflated by CPI	\$100 b/	35.85

a/ Incorrectly reported in Ziemer and White as carcass weight.

b/ Incorrectly reported in Ziemer and White as \$1000/capita.

and substituting (2) and (6) into (4) we obtain

$$(8)\quad Q_t = \beta_0 + \beta_1 PC_{t-2} + \beta_2 C_t + \beta^* P_t + \lambda^* dP_t^- + v_t$$

where $dP_t^+ = \begin{cases} dP_t & \text{if } dP_t > 0 \\ 0 & \text{otherwise,} \end{cases}$

$dP_t^- = \begin{cases} dP_t & \text{if } dP_t < 0 \\ 0 & \text{otherwise,} \end{cases}$

$\lambda^* = 1/\lambda.$

While the system (7) and (8) is now written in observable variables, three estimation problems remain: simultaneity, where Q_t is determined simultaneously with P_t, and also with dP_t^+ and dP_t^- which are functions of P_t; nonlinearity, for while Q_t is a linear function of dP_t^+ and dP_t^-, the latter are step-functions of dP_t; and a cross-equation constraint, where λ^* appears in both (7) and (8).

To estimate (7) and (8), Ziemer and White adopt a full-information maximum-likelihood (FIML) estimator, developed by Laffont and Garcia, which is both consistent and asymptotically efficient under the assumptions of the model. To compare the disequilibrium approach with a more conventional equilibrium model, the equilibrium condition $S_t = D_t = Q_t$ is imposed on equations (1) and (2), and this system is estimated with two-stage least squares (2SLS). For both models, quarterly data over 1965-1979 are used in estimation.

In terms of estimated parameters, both the disequilibrium and the equilibrium models have logical signs, except for the coefficient on the pork price, which is negative in both cases. Demand elasticities with respect to the own and nonfed beef price are about one-third higher in the equilibrium model, while the income elasticity is only 13% greater. The supply-price elasticity for the equilibrum model is about 30% lower. The equilibrium hypothesis is tested by testing if λ^* is significantly different from zero, implying a finite λ. The hypothesis of instantaneous price adjustment is rejected.

In comparing the two models, Ziemer and White emphasize forecasting over parameter estimation. Forecasts of the fed beef price are evaluated with respect to two measures, the root-mean-squared-error and the regression of predicted on actual prices. Evaluations are made for two time periods: the sample period plus two extra quarters outside the sample; the years 1971-1974 when, it has been argued, government wage and price controls created significant disequilibrium in the fed beef market. Over the sample period, the equilibrium model is found to forecast as well as the disequilibrium model, while the latter does noticeably better during the suggested "disequilibrium period." Ziemer and White conclude that their results demonstrate the value of using disequilibrium models to forecast during times of "extreme market disturbances."

Critique of Model

While Ziemer and White's effort does represent a departure from previous models of the fed beef market, a number of problems exists with their approach. These may be raised with respect to their use of disequilibrium theory, in general and in its particular application to fed beef, and to the statistical model estimated. Statistical questions are posed which form the basis for re-estimation of their model. Criticisms of a more theoretical nature are made with an eye toward improved modelling of disequilibrium situations.

Uncertainty and Role of Expectations

Equilibrium models often incorporate some disequilibrium elements through the use of lags to capture costs of quantity adjustments and expectation formation. Such formulations are often (admittedly) ad hoc. But specification of one of the various forms of distributed lags generally presents far fewer estimation problems than the disequilibrium model, while recognizing some of the problems in applying abstract theoretical models to real world situations.

The topic of expectations' formation, and the distinction between actual and desired actions, also suggest a possible misspecification of Ziemer and White's original supply and demand functions. As mentioned above, these relationships represent notional or unconstrained behavior. Given that uncertainty has been identified as a necessary element of disequilibrium, one might expect that disequilibrium models would incorporate decision-making under uncertainty into their notional relationships.

The role of expectations is recognized in many disequilibrium models. Most often, this involves a firm's expectations about a stochastic demand curve or demand shifter, where disequilibrium is modelled within a monopolistic competition context (Eckard; Gordon and Hynes). Sahling adds to these expectations on input prices, and Grandmont and Laroque consider price expectations by both firms and consumers. In Carlton's search model, firms and consumers are expected maximizers, with consumer uncertainty about the availability of a good, and firms facing demand uncertainty. In Laffont and Garcia, a distributed lag of industrial production is used for expectations on the level of general economic activity.

Those modelling the U.S. beef sector have made extensive use of lagged values. When a reason is given for this, producer expectations are identified as an important factor determining supply. Crom, and Langemeir and Thompson include lagged prices in supply without giving a reason, while Reutlinger specifically mentions expectations. Freebairn and Rausser eventually settle on an arithmetic lag structure to represent expectations' formation.

Others describe beef producers' expectations as being more affected by changes, rather than levels, in prices. Some even attribute the beef cycle to the resulting swings in expectations (McCoy: 64). Nelson and Spreen hypothesize an extrapolative expectations' model for feedlot operators, where the estimated supply functions involve price change variables. Hayenga and Hacklander also include the change in price in their supply equation. Given such specifications, it is interesting to note that one major difference between Ziemer and White's equilibrium and disequilibrium models is that the latter, equations (7) and (8), includes price change variables.

Not only have producer price expectations been regarded as an important element of the beef market in "normal" times, they are also crucial to an understanding of what happened with wage and price controls. While various government controls were in effect throughout 1971-1974, discussions of beef market disruptions emphasize the time of retail meat price ceilings, for beef the period March 29 to September 10, 1973, plus the following months.3/ At this time, withholding of cattle, both from placement on feed and from marketing those already on feedlots, drove producer prices to record highs. This created a serious cost squeeze on packers and retailers, leading to plant closings and slowdowns, and distortions like black markets and custom slaughtering.

Why did producers withhold cattle, especially with the relatively high returns to cattle feeding prevailing at the time, plus the "high transactions costs to maintaining marketable livestock on feedlots" mentioned by Ziemer and White? These costs must be considered against the expected returns to withholding. In the months just prior to the imposition of price ceilings, beef prices were rising sharply, and producers expected such increases to continue into the near future. Government controls merely deferred these expectations to September 11, the date, announced at the time ceilings were imposed, when controls would be lifted.4/

> Since it had been announced when the freeze would end, it was their [beef producers] intention to hold back supplies and wait for the increase in prices that were expected when controls were over. (Dunlop and Fedor: 85)

This strategy of withholding supplies ultimately worked against producers, causing a market glut of heavy cattle in the post-ceiling period with cattle feeders sustaining heavy losses.

Price Determination, Imperfect Competition, and Equilibrium

Besides uncertainty, another integral element of disequilibrium analysis is price inflexibility, usually attributed to some sort of imperfect information. To this Ziemer and White add imperfect competition, concluding actual beef prices may not be at "competitive levels," thereby justifying a disequilibrium approach.

Ziemer and White's market concentration argument actually skirts the issue - the establishment of an equilibrium price, competitive or

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3/ The first retail price freeze in 1971 is thought to have created limited disruption due to seasonal increases in supply and low feed costs. At other times during the economic stabilization program, raw agricultural prices were left uncontrolled, with processors and others allowed to pass-through any price increases (see Mills, Eckstein and Heien, and especially Dunlop and Fedor for the impacts of government controls).

4/ Price ceilings on beef were actually removed a day earlier.

otherwise. Though the two behavioral relationships in the model are labelled supply and demand, thus evoking the textbook explanation of an aggregation of individuals' desired actions taking prices as given, there is nothing in the actual specification which prevents the solution of such a system of equations from representing a non-competitive equilibrium. If the bargaining or other process determining the equilibrium is relatively stable over time, this process could well be captured by the estimated coefficients of an equilibrium model, and without a structural change, the estimated model may forecast quite well.5/

Actually, disequilibrium itself is inconsistent with perfect competition, violating the assumption that agents may buy or sell as much as they desire at the existing market price. With disequilibrium, one does not need market concentration in the usual sense to have imperfect competition. Much of disequilibrium analysis has adopted a framework of imperfect competition, and various authors (Rothschild; Sahling; Barro and Grossman) refer to an earlier observation of Kenneth Arrow: "In disequilibrium the market consists of a number of monopolists facing a number of monopsonists" (cited in Gordon: 520). This approach explicitly models price setting because, as pointed out by Grandmont and Laroque, to simply specify price adjustment as a function of excess demand amounts to reintroducing Walras' auctioneer. Typically firms are assumed to act as price setters, usually within a monopolistic competition setting (Gordon; Gordon and Hynes; Grandmont and Laroque; Kling; Eckard; Rothschild; Carlton).

Some "disequilibrium" models even embody equilibrium concepts, though what constitutes an equilibrium in such situations varies. Within a search context, Rothschild reviews a number of models with a host of different equilibria: Nash, competitive, monopolistic, something between the former and the latter, signalling and informational equilibria. Disequilibrium macroeconomics has developed the notion of a Keynesian or fixed price equilibrium (Loroque; Grandmont and Larogue; Benassy; Korlivas; Gordon).

Do models of non-Walrasian behavior require some sort of equilibrium? Rothschild argues yes, that broader equilibrium concepts are needed for these models to be consistent, and to be useful for further theoretical development and policy analysis. Gordon, and Nerlove, however, question the importance of a static, long-run equilibrium in such situations. Both recommend greater attention to modelling dynamic behavior.

5/ The problem of a change in market structure also creates an estimation problem for the disequilibrium model in general, and Ziemer and White's estimated model in particular. During the sample period, the fed beef sector experienced a rapid increase in seller concentration, accompanied by increased integration of large commercial feedlots and packers (Gee, Van Arsdall, and Gustafson; Martin; McCoy; Reimund, Martin, and Moore). To the extent that market structure affects price determination, this change suggests instability of the estimated coefficient in Ziemer and White's price adjustment relationship.

Statistical Questions

While the above discussion questions the conceptual foundation for specifying a disequilibrium model for the beef sector, questions remain about the estimation of both the disequilibrium and equilibrium models as well as the specific specification of the supply equation. These questions raise doubts about the validity of Ziemer and White's evaluation of results.

As mentioned previously, Ziemer and White's disequilibrium model is estimated with a full-information technique which, assuming a correct model specification, would result in asymptotically efficient estimates. The disequilibrium model's forecasting ability is then judged against that of an equilibrium model estimated with 2SLS. But 2SLS is known to be an inefficient estimator in this case, since both the supply and demand equations are overidentified. If a full-information estimator had been applied to the equilibrium model, the comparison of forecasts would, in this sense, have been "fairer," each model having been estimated efficiently.

A second possible problem relates to the cross-equation constraint imposed on λ^*, the reciprocal of the speed of price adjustment. This constraint originates from the particular specification adopted for price adjustment, one which implies prices move up and down with equal flexibility. In a more general formulation of the disequilibrium model, Ito considers the possibility of varying speeds of adjustment. To the extent that the cross-equation constraint on λ^* is "true," there is a gain in efficiency. But if the data do not support the constraint, imposing it is a specification error. In two other empirical applications of the disequilibrium model, removing this constraint has resulted in large changes in the estimated coefficient, with upward price flexibility more than twice as rapid as downward adjustment (Fair and Jaffee; Laffont and Garcia). While in neither case do other coefficients change very much, this possibility remains.

The most serious potential problem with Ziemer and White's estimation is autocorrelation. When Durbin-Watson statistics or residual time-plots have been reported for other beef sector models, autocorrelation is almost inevitably present. And the degree of autocorrelation is often severe, with Durbin-Watson statistics as low as 0.4 (Reutlinger; Freebairn and Rausser; Langemeier and Thompson; Arzac and Wilkinson). Ziemer and White do not present any information concerning the presence of autocorrelation, but given the autocorrelation of previous studies plus the similarities in model specification, serially correlated errors could also be a problem in their model.

If their model is indeed autocorrelated, this has three serious implications for Ziemer and White's results and conclusions. First, it invalidates their test of $\lambda^*=0$ and their rejection of the equilibrium hypothesis. Second, it can perhaps explain the superior forecasting of the disequilibrium model, which effectively includes P_{t-1} as a variable (since P_{t-1} is an element of dP_t). If prices are autocorrelated, lagged price would capture some of the effect of the autocorrelated disturbances. This could result in more accurate forecasts because, with autocorrelation of residuals, the best linear forecast involves lagged values (Johnston: 265-266). Third, serially correlated residuals suggest that the equations may be misspecified.

Estimation and Forecasts

In re-estimating the fed beef model, emphasis is placed on the statistical problems outlined above. Estimation procedures are given greater attention than model specification for several reasons. First, retaining the original supply and demand specifications facilitates comparisons with the results of Ziemer and White's FIML estimation, re-estimation of which is not attempted. Second, a hypothesis underlying re-estimation is that inappropriate estimation of the equlibrium model may explain its shortcomings as a forecaster. Finally, concentrating on estimation is appropriate to an overall evaluation of the disequilibrium approach, given the enormous difficulties in estimating disequilibrium models.6/ A respecification of the supply equation is, however, considered. Thus, re-estimation covers the following: three-stage least-squares (3SLS) estimation of the equilibrium model; a two-stage estimation of the disequilibrium model, with and without the cross-equation constraint on λ^*; a two-stage generalized least-squares estimation of the equilibrium model, correcting for first-order autocorrelation. Results for each are first presented and discussed individually, while forecasting ability is handled jointly.

The original data set, obtained from Ziemer, is used, but preliminary analysis of the data revealed a significant error in two income observations. The estimated coefficients in the demand equation are very sensitive to this error, and these observations are also important to the forecasting evaluation, since they fall within the disequilibrium period, 1971-1974. In response, a revised data set was created, substituting new values for the two erroneous entries. The revised data set then is used for both estimation and forecasting purposes.7/

Three-Stage Least Squares

Tables 2 and 3 compare 2SLS and 3SLS results. For both supply and demand, the use of the more efficient estimator causes large changes in estimated coefficients only with the original data set. The largest change occurs for the lagged placements-on-feed coefficient, which falls by more than 50%, and most other coefficients change by a considerable amount. Many of these changes represent movements away from the FIML disequilibrium results, where the cross-equation covariance of error terms is apparently assumed to be zero.

The implied greater efficiency of 3SLS over 2SLS, however, can be mostly attributed to the data error. Using the original data, the correlation coefficient between the 2SLS supply and demand residuals is 0.65. With the revised data set, the correlation drops to 0.11, and there is little difference between 2SLS and 3SLS estimated coefficients or standard errors. The data error itself, though, causes large changes in some estimated coefficients, particularly in the demand equation.

6/ Fair and Kelejian provide a summary of estimation of single-market disequilibrium models.

7/ The appendix provides more detail about the data error, the impact of deleting these observations, and the method used to obtain substitute values for the revised data set. The errors in observations also explain the inconsistent results found in Shonkwiler and Spreen's comment versus Ziemer and White's reply.

Table 2

2SLS and 3SLS Demand Estimates, Equilibrium Model

Data Set, Estimation Method	Regression Coefficients					D.W.
	Constant	P	UCP	HP	Y	
Original Data:						
2SLS	588.0 (0.798)	-72.01 (-1.782)	89.75 (2.316)	-9.148 (-0.639)	172.2 (6.379)	0.67
3SLS	2387 (4.124)	-88.26 (-2.432)	118.1 (3.290)	5.768 (0.5070)	106.1 (5.073)	0.38
Revised Data:						
2SLS	-3831 (-5.120)	-128.1 (-4.323)	115.8 (4.229)	-13.71 (-1.375)	342.4 (12.03)	0.66
3SLS	-3416 (-4.592)	-127.9 (-4.328)	118.3 (4.331)	-11.57 (-1.167)	326.8 (11.55)	0.63

t-ratios in parentheses D.W. = Durbin-Watson statistic

Table 3

2SLS and 3SLS Supply Estimates,
Equilibrium Model

Data Set, Estimation Method	Regression Coefficients: Constant	P	PC_{-2}	C	D.W.
Original Data:					
2SLS	4195 (10.77)	43.34 (3.934)	0.1526 (2.375)	-42.09 (-2.420)	0.89
3SLS	4555 (13.07)	51.40 (4.986)	0.06874 (1.377)	-51.01 (-3.027)	0.71
Revised Data:					
2SLS	4193 (10.74)	44.28 (4.011)	0.1502 (2.332)	-43.12 (-2.474)	0.89
3SLS	4239 (10.89)	45.33 (4.114)	0.1394 (2.178)	-44.30 (-2.543)	0.86

t-ratios in parentheses D.W. = Durbin-Watson statistic

In comparing 2SLS with 3SLS output, the Durbin-Watson statistic is one result which remains quite stable. Though the Durbin-Watson test does not strictly apply in this situation, the fact that this statistic is consistently so small may be taken as an indication of serial correlation. And with autocorrelation, even 3SLS is not asymptotically efficient, while standard formulas incorrectly calculate least-squares variances.

Unconstrained Disequilibrium Model

To re-estimate the disequilibrium model, a two-stage least-squares estimator suggested by Amemiya is adopted. For the first stage, the three right-hand side endogenous variables in equations (7) and (8) - P_t, dP^+_t, dP^-_t - are regressed (OLS) on all exogenous variables. Predicted values from these regressions are then substituted for actual values to estimate (7) and (8). Though consistent, Amemiya's estimator is not asymptotically efficient for two reasons: it ignores the implied cross-equation constraint on λ^*; and predicted values $\hat{dP}^+_t$ and $\hat{dP}^-_t$, linear functions of the exogenous variables, are used in place of dP^+_t and dP^-_t, which are actually non-linear functions of the exogenous variables.8/

Amemiya's estimator is applied in two ways. First, demand and supply are estimated separately, as described above. Then, to impose the cross-equation constraint on λ^*, the second stage of the procedure is modified so that (7) and (8) are estimated jointly. This is accomplished by "stacking" the data matrices for the two equations into one matrix, much in the way 3SLS is formulated. The difference here is that the two equations are linked by a structural coefficient rather than a covariance of random errors.9/

Results of the disequilibrium re-estimation are given in Tables 4 and 5, along with Ziemer and White's original findings. Despite its inefficiency, many estimated coefficients from the constrained, Amemiya-type regression are quite close to those from the FIML estimator. The largest difference is the estimate of λ^*, which is negative in all cases, with very large standard errors. The own-price supply coefficient and the nonfed beef price coefficient are also noticeably different.

8/ This assumes that the random errors in (7) and (8) are uncorrelated. Without this assumption, failure to account for this correlation would be a third source of inefficiency.

9/ In the joint estimation procedure, the difference in random error variances for (7) and (8) is not taken into account in estimation, i.e., ordinary rather than generalized least squares is applied to the stacked data matrix. This simplification probably has little effect with the original data set, since standard errors of the regression from the unconstrained demand and supply estimations are nearly the same. But with the revised data, the standard error of estimate in the supply equation is more than twice that of the demand error, implying more serious heteroscedasticity and problems with computed t-ratios, etc.

Table 4

Demand Estimates, Disequilibrium Model, Original and Revised Data Sets

Data Set, Estimation Method	Cross-Equation Constraint[a]	Regression Coefficients					
		Constant	P	UCP	HP	Y	$-dP^{+}$
Original Data:							
FIML	Yes	1381.14 (2.641)	-55.1454 (-4.028)	66.7723 (13.511)	-17.3468 (-3.338)	152.058 (11.203)	90.3000 (12.398)
2SLS[b]	No	1318 (1.19)	-54.13 (-0.98)	61.03 (1.09)	-18.29 (-0.90)	154.7 (4.10)	-140.6 (-1.20)
2SLS	Yes	1425 (1.20)	-51.23 (-0.89)	56.01 (0.97)	-19.87 (-0.95)	152.3 (3.88)	-167.0 (-1.54)
Revised Data:							
2SLS	No	-4054 (-5.24)	-120.4 (-4.09)	97.95 (3.34)	-20.57 (-1.91)	355.3 (11.88)	-78.23 (-1.47)
2SLS	Yes	-4209 (-3.36)	-114.8 (-2.41)	85.04 (1.81)	-25.53 (-1.48)	364.5 (7.56)	-134.6 (-1.72)

t-ratios in parentheses

a/ Cross-equation constraint: Reciprocal of the speed of price adjustment (λ*) constrained to be equal in the supply and demand equations.

b/ Uses procedure suggested by Amemiya, see text.

Table 5

Supply Estimates, Disequilibrium Model, Original and Revised Data Sets

Data Set, Estimation Method	Cross-Equation Constraint[a/]	Regression Coefficients				
		Constant	P	PC_{-2}	C	dP^-
Original Data:						
FIML	Yes	3873.00 (12.922)	60.3543 (6.718)	0.2013 (10.707)	-68.9145 (-7.955)	90.3000 (12.398)
2SLS[b/]	No	4138 (9.61)	43.72 (3.84)	0.2210 (2.29)	-78.23 (-2.04)	-263.3 (-1.06)
2SLS	Yes	4193 (10.78)	43.16 (4.04)	0.1935 (2.78)	-64.96 (-2.89)	-167.0 (-1.54)
Revised Data:						
2SLS	No	4057 (7.78)	45.31 (3.29)	0.2566 (2.20)	-97.23 (-2.11)	-395.0 (-1.33)
2SLS	Yes	4208 (13.52)	43.86 (5.12)	0.1821 (3.33)	-61.46 (-3.57)	-134.6 (-1.72)

t-ratios in parentheses

a/ Cross-equation constraint: Reciprocal of the speed of price adjustment (λ^*) constrained to be equal in the supply and demand equations.

b/ Uses procedure suggested by Amemiya, see text.

Imposition of the constraint on λ^* affects estimated supply parameters more than demand coefficients. In particular, the price of corn coefficient drops sharply with both data sets. The t-ratios in the supply equation also improve with the constraint. As before, more dramatic changes in estimated coefficients result when the data error is corrected. Again, the income coefficient is most affected, followed by the other parameters in the demand equation.

Generalized Two-Stage Least Squares

The estimates presented above strongly suggest that the residuals are autocorrelated, an anticipated outcome. Thus, the final set of estimates correct the equilibrium model for first-order autocorrelation. With equations (1) and (2) plus an equilibrium condition, the model specification now includes the additional assumption

$$u_t = \rho^D u_{t-1} + w_t$$

$$v_t = \rho^S v_{t-1} + e_t$$

where ρ^D and ρ^S are parameters to be estimated, and the classical assumptions are now made for w_t and e_t.

To estimate the model, a two-step, generalized least-squares method is used.10/ Sargan's two-stage least squares (S2SLS) differs from ordinary 2SLS in two respects: lagged values of all variables in the model are added to the reduced form for the price of beef; the second stage is a generalized least-squares estimator, where ordinary least squares is applied to the transformed equations

$$(9)\quad Q_t - \rho^D Q_{t-1} = \alpha_0(1-\rho^D) + \alpha_1(UCP_t - \rho^D UCP_{t-1}) + \alpha_2(HP_t - \rho^D HP_{t-1}) + \alpha_3(Y_t - \rho^D Y_{t-1}) + \alpha^*(\hat{P}_t - \rho^D P_{t-1}) + w_t$$

$$(10)\quad Q_t - \rho^S Q_{t-1} = \beta_0(1-\rho^S) + \beta_1(PC_{t-2} - \rho^S PC_{t-3}) + \beta_2(C_t - \rho^S C_{t-1}) + \beta^*(\hat{P}_t - \rho^S P_{t-1}) + e_t$$

with $\hat{P}_t$ being the predicted values from the reduced form. The generalized least-squares step scans over grids on ρ^D and ρ^S. Final results are presented for the values of ρ^D and ρ^S which minimize the sum of the squared residuals of (9) and (10). Though S2SLS is not efficient, it is consistent. Consistent estimates of asymptotic error variances may be computed as well.11/

10/ Fair gives a formal treatment of estimation methods for simultaneous systems with autocorrelated errors.

11/ Estimates of asymptotic standard errors and t-ratios are computed using the method suggested by Fair (p. 514). The formulas assume ρ^D and ρ^S are known rather than estimated, which greatly simplifies the calculations.

As an alternative approach to the autocorrelation problem, Ziemer and White's original specification is changed. Because time plots of supply residuals showed signs of seasonality, quarterly dummy variables are added to the supply equation. Possible reasons for adding dummy variables include the influence of season of the year on weight gain, plus seasonal variations in the weight and composition (steers vs. heifers) placed on feed. With quarterly dummies, the Durbin-Watson statistic from the ordinary 2SLS supply estimation improves dramatically, jumping to 1.53 from previous levels of 0.8-0.9. Because of this improvement and the high cost of S2SLS estimation, for this set of regressions it is assumed $\rho^S=0$. With this assumption, the S2SLS reduced form no longer includes lagged predetermined variables from the supply equation, and only demand is estimated by generalized least squares.

Results of S2SLS regressions are given in Tables 6 and 7. The degree of autocorrelation is high, with estimated values for ρ^D and ρ^S of 0.8 or greater. Compared with ordinary 2SLS demand estimations, the own- and non-fed beef cross-price effects increase in magnitude when the original data are used, but there is little change with the revised data. With the original data accounting for autocorrelation has a large impact on the income coefficient, which falls to a very low level, while generalized least squares pulls the revised data coefficient down to a reasonable value.

Supply equation estimates are greatly affected by re-estimation. Except for the intercept, all coefficients are driven towards zero. The final parameter estimates are so small, with such low t-ratios, that estimated supply almost appears as a purely autoregressive process. The addition of seasonal dummies still results in a small and insignificant coefficient for the current beef price, but lagged cattle placements retains a large and significant effect, which is consistent with results obtained independently by Shonkwiler and Spreen.

Forecasting

To evaluate forecasting, four estimators are considered: the FIML disequilibrium model; the 2SLS, 3SLS, and S2SLS estimates, using the original data, of the equilibrium model. The price of fed beef is forecast from the solved reduced forms of each model. Forecasts are made with both the original and revised data, with separate comparisons for two time periods: the sample period (1965-1979) and the disequlibrium period (1971-1974). Evaluation criteria are two root-mean-squared error statistics, plus results from simple regressions of predicted on actual prices.12/

Measures of forecasting ability with the original data set are given in Table 8. For the sample period, the 3SLS and S2SLS equilibrium models perform noticeably better with respect to most measures than the disequilbrium

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12/ The forecasting evaluation here differs in two respects from that of Ziemer and White. First, the sample period does not include the two extra 1980 observations, these being unavailable to the author. Second, the root-mean-square-error measures adopted vary from the statistic in the original article, which I was unable to derive.

Table 6

S2SLS Demand Estimations, Equilibrium Model, Original and Revised Data Sets

Data Set, Specification	$\hat{\rho}^D$	Regression Coefficients: Constant	P	UCP	HP	Y
Original Data	0.94	6894 (7.85)	-115.9 (-6.55)	119.8 (6.67)	6.617 (0.92)	24.37 (1.33)
Revised Data:						
Without Seasonality	0.80	-585.6 (-0.36)	-119.8 (-6.25)	121.8 (6.28)	2.052 (0.28)	224.7 (4.49)
With Seasonality	0.80	-779.4 (-0.46)	-134.0 (-7.80)	134.3 (7.45)	4.579 (0.63)	234.0 (4.57)

t-ratios in parentheses

Table 7

S2SLS Supply Estimations, Equilibrium Model, Original and Revised Data Sets

Data Set, Specification	Regression Coefficients							
	$\hat{\rho}^S$	Constant	P	PC_{-2}	C	D1	D2	D3
Original Data	0.87	6696 (9.80)	-9.165 (-0.62)	0.02011 (0.75)	-11.77 (-0.52)			
Revised Data:								
Without Seasonality	0.88	6875 (9.87)	-14.18 (-0.97)	0.02266 (0.87)	-9.425 (-0.42)			
With Seasonality	0	2209 (5.86)	1.489 (0.18)	0.7495 (8.46)	-13.18 (-1.15)	-59.98 (-0.38)	-2041 (-7.14)	-92.01 (-0.62)

t-ratios in parentheses

D1, D2, and D3 = dummy variables for the first, second, and third quarters, respectively.

Table 8

Evaluation of Forecasting Fed-Beef Price with Original Data, Sample and Disequilibrium Periods

Time Period, Model	Regression Results[a/] $\hat{\gamma}_0$	$\hat{\gamma}_1$	R^2	RMSE1 (\$)	RMSE2 (%)
Sample Period:					
Disequilibrium	4.93 (3.42)	0.824 (-4.79)	.899	4.17	10.2
2SLS Equilibrium	2.05 (1.17)	0.945 (-1.23)	.886	4.03	11.1
3SLS Equilibrium	2.05 (1.31)	0.945 (-1.64)	.933	3.04	7.85
S2SLS Equilibrium	0.254 (1.18)	0.993 (-0.23)	.951	2.64	6.74
Disequilibrium Period:					
Disequilibrium	-2.37 (-0.40)	1.05 (0.30)	.773	3.07	7.63
2SLS Equilibrium	-12.4 (-1.74)	1.38 (2.08)	.802	4.74	12.3
3SLS Equilibrium	-10.7 (-2.27)	1.31 (2.56)	.894	3.16	7.78
S2SLS Equilibrium	3.91 (4.81)	0.898 (-0.83)	.792	2.50	6.25

$$\text{RMSE1} = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(P_t-\hat{P}_t)^2} \qquad \text{RMSE2} = \sqrt{\frac{1}{N-1}\sum_{t=1}^{N-1}\left(\frac{P_{t+1}-\hat{P}_{t+1}}{P_t}\right)^2}$$

where P_t = actual price, $\hat{P}_t$ = predicted price.

a/ Regression: $\hat{P}_t = \gamma_0 + \gamma_1 P_t + e_t$. T-ratios in parentheses are for the tests $\gamma_0=0$ and $\gamma_1=1$.

model. Generalized least squares is shown to lead to greater improvement in 2SLS predictions than full-information estimation. Under the chosen criteria, the S2SLS equilibrium model is the best forecaster over the entire sample period.

The period 1971-1974 presents a more mixed picture. Based on a root-mean-square-error criterion, disequilibrium and 3SLS equilibrium model forecasts are comparable, while those of the S2SLS estimation are somewhat better. But from the regressions of predicted on actual prices, all equilibrium models give stronger indications of biased forecasts. The point to be emphasized is that the FIML disequilibrium model, when compared with re-estimated equilibrium models, is no longer an unambiguously better forecaster.

Predictions from the disequilibrium model are also more sensitive to the data error, seen by comparing Table 8 with statistics of revised data forecasts, Table 9. While the equilibrium models, especially the 2SLS version, generally show an improved performance when the data error is corrected, disequilibrium model forecasts in the disequilibrium period worsen with respect to a number of measures. Ironically, even the 2SLS equilibrium model now appears to predict better than the disequilibrium model over this period.

Evaluation of the Disequilibrium Approach

At this time, the number of empirical applications of the single-market disequilibrium model adopted by Ziemer and White remains limited. Still, enough work has been done to allow for at least a preliminary evaluation of this approach, and consideration of its advantages and disadvantages compared with a more traditional, equilibrium framework. Such a review can also be useful in suggesting new ways to model the phenomena leading to market failure and disequilibrium.

The main disadvantage of the disequilibrium model appears to be the computational problems to obtaining "good" estimates of the structural parameters. "Good" is taken here to include statistical properties like consistency and efficiency, plus the practical concerns of computing expense and robustness or stability of results.

On the one hand, there are estimation techniques for the disequilibrium model which are relatively easy to compute using available statistical packages. Fair and Jaffee present a number of these directional methods, where the total sample is first divided a priori into periods of excess demand and excess supply, with observations from the former period then used to estimate supply parameters, and data from the other to estimate demand. These estimators, however, are neither consistent nor efficient.

To go on to Fair and Jaffee's quantitative method first requires the rather strict specification of proportional, yet deterministic, price

Table 9

Evaluation of Forecasting Fed-Beef Price with Revised Data, Sample and Disequilibrium Periods

Time Period, Model	Regression Results $\hat{\gamma}_0$	$\hat{\gamma}_1$	R^2	RMSE1 (\$)	RMSE2 (%)
Sample Period:					
Disequilibrium	5.10 (3.52)	0.815 (-5.04)	.896	4.32	10.6
2SLS Equilibrium	2.40 (1.49)	0.926 (-1.95)	.911	3.53	9.69
3SLS Equilibrium	2.23 (1.83)	0.935 (-2.08)	.940	2.88	7.40
S2SLS Equilibrium	0.212 (1.18)	0.994 (-0.19)	.951	2.64	6.73
Disequilibrium Period:					
Disequilibrium	2.56 (0.38)	0.900 (-0.57)	.655	3.74	9.43
2SLS Equilibrium	-2.45 (-0.46)	1.09 (0.62)	.818	2.88	6.82
3SLS Equilibrium	-5.59 (-1.23)	1.16 (1.36)	.875	2.52	5.90
S2SLS Equilibrium	3.17 (4.86)	0.917 (-0.67)	.795	2.51	6.24

See notes, bottom of Table 8.

adjustment.13/ With this approach, Amemiya's estimator may be computed without too much difficulty, thereby achieving consistency. But as seen in the applications to the fed beef model and in Laffont and Garcia's demand equation, this estimator is quite inefficient compared to maximum likelihood. Thus, maximum likelihood would appear to be the preferred estimation method. This requires the use of a non-linear optimization algorithm, not always readily available, which brings with it the concerns of convergence, local maxima, and computing expense.

Autocorrelation creates additional statistical complications for the disequilibrium model. Given the extent of this problem in empirical work, the inability of disequilibrium models to effectively deal with serial correlation is a serious handicap. Fair and Kelejian state that for consistent estimation, the basic disequilibrium model is underidentified. The source of underidentification is that, within the disequilibrium framework, either D_{t-1} or S_{t-1} (lagged notional demand or supply) is unobservable at any one point in time, while observations on both are needed for consistency.

Fair and Kelejian do discuss correcting for autocorrelation within a directional estimation method, though estimates obtained in this manner are still inconsistent. One is also likely to encounter degrees of freedom difficulties, since one observation is lost per switching point, i.e., a switch from a period of excess demand to excess supply, and vice versa. Ziemer and White's data have thirty switching points, scattered throughout the sixty observations in such a way that the demand function could not be estimated with this technique. Recognizing the need to conserve degrees of freedom yet still account for autocorrelation, Fair and Jaffee assume that for each switching point $S_{t-1} = D_{t-1} = Q_{t-1}$, that is, equilibrium. This assumption goes against the whole spirit of disequilibrium analysis, and with many switching points, the results may not differ much from those of an equilibrium model.

One final, potential concern about disequilibrium models, especially those estimated with FIML, is the sensitivity of results to specification error and errors in variables. There is no clear evidence that disequilibrium models are less robust than equilibrium ones. In a Monte Carlo study of the Fair and Jaffee model, Quandt finds the two about equally sensitive to model misspecification. On the other hand, forecasts with the fed beef models show the disequilibrium model's predictive ability declines noticeably using "correct" income values, while forecasts with the equilibrium models generally improve. Laffont and Garcia also note the sensitivity of their parameter estimates to different price adjustment specifications.

13/ Likelihood functions have been derived for disequilibrium models which exclude a price adjustment relation all together, or where the equation includes a random error. For these specifications, the separation of the sample period into excess demand and supply regimes is endogenous, and is estimated along with the other parameters. While Quandt, and Rosen and Quandt, report no problems with this approach, Fair and Jaffee, Laffont and Garcia, and Fair and Kelejian all had great difficulties, particularly with local optima of the likelihood function.

The statistical and computational disadvantages of disequilibrium models must be weighed against the potential advantages. And what constitutes an advantage can only be determined in light of the stated objectives of a research project. Intriligator identifies three principal uses of econometric models: structural analysis, the quantification of relationships implied by economic theory to promote greater understanding, while also allowing for the validation of the theory and testing of hypotheses; forecasting; and policy evaluation, either the selection of a "best" policy using statistical estimates of the structural parameters, or simulation of policy alternatives to determine likely impacts.

In the area of structural analysis, the main use of disequilibrium models has been to statistically test the equilibrium hypothesis (Fair and Jaffee; Laffont and Garcia; Ziemer and White). The equilibrium hypothesis is always rejected. Laffont and Garcia go on from this to conclude "the necessity of using disequilibrium methods." This ignores the many problems associated with statistical tests, the proper interpretation of which is actually conditioned on correct specification of the rest of the model. It also attempts to justify the estimation of disequilibrium models as a purpose unto itself, while econometric models are often asked to serve a number of different purposes. The estimated coefficients from disequilibrium models are so similar to those of equilibrium versions that the disequilibrium approach has yet to demonstrate any additional advantages for structural analysis.

Beyond testing the equilibrium hypothesis, econometric disequilibrium models have seen limited use. Ziemer and White's emphasis on forecasting is an exception. In this case, re-estimated equilibrium models prove to be equally good, if not better, forecasters. Therefore, based on this limited evidence, there does not appear to be any special advantages, in terms of forecasting, to using disequilibrium models (see also Baumes and Womack).

If disequilibrium models produce similar estimates of structural parameters and do not possess superior predictive capacities, are they more useful than equilibrium models in analyzing and evaluating policy choices? Does the knowledge that a market is in disequilibrium lead one to prefer one policy over another, or suggest new policy alternatives? In the author's opinion, the answer to both questions is a qualified no. Disequilibrium models do not offer anything new to policy analysis unless they explicitly model the source of the disequilibrium.

Others involved with the disequilibrium approach - Barro, Grossman, Grandmont and Larogue, Gordon - have recognized the need to address the underlying causes of price inflexibility preventing market clearing. Barro feels that this is particularly important to policy analysis; if the reason for market failure is something like imperfect information, there may not be a strong case for government action.

Grossman finds one exception, when identifying the source of disequilibrium is not an issue. This is where government controls limit price movement, and in these situations disequilibrium models may be useful in investigating the "spillover effects" of disequilibrium from one market into another. Howard's multi-sector model of the USSR is a good example of this. One qualification should be made concerning the use of disequilibrium models for controlled-price situations: disequilibrium implies the potential for profitable arbitrage, and government "controls" are relevant only to the extent that black markets and non-price rationing activities are absent, or at least not widespread.

If the disequilibrium approach is to proceed and explicitly model the source of market failure, there is both existing theoretical and empirical work upon which it can build. Two of the three integral elements of disequilibrium, uncertainty and production lags, have long been incorporated in econometric models. Greater attention to dynamic, disequilibrium behavior may help formalize the largely ad hoc use of lagged variables to represent expectations' formation and costs to quantity adjustment.

Price inflexibility, typically due to imperfect information, is the last component of disequilibrium. Stiglitz observes that the existence of imperfect information causes fundamental changes in the standard concept of a competitive market. Theorists, following Arrow's lead, have turned to price-setting models, usually firms as price-setters within a customer search context. This approach eminates from another observation by Arrow that the monopolistic disequilibrium actions by sellers, the more concentrated side of the market, will be the major force behind price changes (cited in Gordon: 520). For other situations, it may be more appropriate to have price-setting by a limited number of buyers facing many sellers. Bidding and bargaining models are other alternatives. As yet, empirical applications in this area are scarce, Sahling's paper being an exception.

With movements away from a Walrasian-style market have come new equilibrium concepts. Questions remain as to whether non-Walrasian models "need" some sort of equilibria. This is especially true since many of the conceived equilibria are not particularly desireable in welfare terms, unlike a Walrasian equilibrium. But alternative equilibrium notions may help ease the statistical burden of estimating disequilibrium models. Using a fixed price equilibrium, Howard was able to estimate his model with 3SLS, a far simpler procedure than others' attempts with maximum likelihood.

Summary and Conclusions

Disequilibrium analysis, especially its empirical application, is a relatively new avenue for economic theory and econometric modelling. In this paper, the disequilibrium approach has been reviewed, examined, and criticized from different perspectives. Particular attention has been given to Ziemer and White's single-market disequilibrium model of the U.S. fed beef sector, which acts as a base for a broader discussion and evaluation of the disequilibrium approach.

Ziemer and White's fed beef model is first criticized for theoretical inconsistencies and omissions. Specifically, the role of expectations with decision-making under uncertainty and the existence of non-Walrasian equilibria are discussed in questioning Ziemer and White's specification.

With regard to their statistical implementation, three issues are raised: full- vs. limited-information estimation, parameter constraints, and autocorrelation. These statistical problems cast doubts on the validity of Ziemer and White's test of the equilibrium hypothesis, and their comparison of forecasting ability of the equilibrium and disequilibrium models.

Re-estimations of the fed beef model do show a high degree of autocorrelation with the equilibrium specification. This assumedly carries over to the disequilibrium model, invalidating Ziemer and White's statistical test of equilibrium. Re-estimation also improves the forecasting accuracy of the equilibrium model such that the disequilibrium model can no longer be considered an unambiguously superior forecaster of the fed beef price.

In the overall evaluation, statistical and computational problems are identified as the major disadvantages to continued empirical use of the Ziemer and White type disequilibrium model. Other than testing the equilibrium hypothesis, such models have yet to demonstrate any gains over their equilibrium counterparts in the areas of structural analysis, forecasting, or policy analysis. It is concluded that, to realize the full potential of this approach, disequilibrium analysis must move forward and explicitly model the sources of market failure.

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Appendix

Upon inspecting the fed beef data received from Ziemer, the author noticed what appears to be an obvious data error. The time-series for real per capita income were given as follows (showing two quarters before and after the apparent errors):

Year-Quarter	Real Per Capita Income
1972-3	36.3890
-4	37.4386
1973-1	46.5643
-2	45.4242
-3	38.2476
-4	38.2404

The data imply that, from 1972-4 to 1973-1, real per capita income grew at an annual rate of nearly 25%, only to decline almost as sharply two quarters later. Clearly the first two observations for 1973 are in error.

Appendix Table 1 demonstrates how influential the two erroneous income entries are on 2SLS estimated coefficients. Deleting these observations causes large changes in estimated demand parameters, especially those for income and the fed beef price.

The author has been unable to derive exactly Ziemer's per capita real income figures from Dept. of Commerce and other sources cited in the original article. But because of the great influence of the two incorrect observations on estimated parameters and their importance to forecasts in the disequilibrium period (1971-1974), corrected values were essential to further analysis. To obtain these, the original income data, less the first two entries of 1973, were plotted across time along with a real per capita disposable income series available from conventional sources. By hand-fitting a curve for the former based upon the latter, the values 38.5 and 38.25 were obtained for the first and second quarters of 1973, respectively. These were then combined with the other income observations from Ziemer's data to form the income variable for the revised data set.

Appendix Table 1

Effect of Data Error on 2SLS Estimations, Equilibrium Model

A. Demand

Data Set	Regression Coefficients: Constant	P	UCP	HP	Y	D.W.
Original data	588.0	-72.01	89.75	-9.148	172.2	0.67
	(0.798)	(-1.782)	(2.316)	(-0.639)	(6.379)	
Deleting 1973-1 and 1973-2	-3888	-132.1	119.8	-12.84	344.8	0.66
	(-4.987)	(-4.256)	(4.176)	(-1.245)	(11.60)	

B. Supply

Data Set	Regression Coefficients: Constant	P	PC_{-2}	C	D.W.
Original data	4195	43.34	0.1526	-42.09	0.89
	(10.77)	(3.934)	(2.375)	(-2.420)	
Deleting 1973-1 and 1973-2	4143	43.26	0.1604	-41.73	0.93
	(10.34)	(3.830)	(2.408)	(-2.335)	

t-ratios in parentheses D.W. = Durbin-Watson statistic